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Evaluating a collaborative IT based research and development project

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ABSTRACT

In common with all projects, evaluating an Information Technology (IT) based research and development project is necessary in order to discover whether or not the outcomes of the project are successful. However, evaluating large-scale collaborative projects is especially difficult as: (i) stakeholders from different countries are involved who, almost inevitably, have diverse technological and/or application domain backgrounds and objectives; (ii) multiple and sometimes conflicting application specific and user-defined requirements exist; and (iii) multiple and often conflicting technological research and development objectives are apparent. In this paper, we share our experiences based on the large-scale integrated research project – *The HUMBOLDT project* – with project duration of 54 months, involving contributions from 27 partner organisations, plus 4 sub-contractors from 14 different European countries. In the HUMBOLDT project, a specific evaluation methodology was defined and utilised for the user evaluation of the project outcomes. The user evaluation performed on the HUMBOLDT Framework and its associated nine application scenarios from various application domains, resulted in not only an evaluation of the integrated project, but also revealed the benefits and disadvantages of the evaluation methodology. This paper presents the evaluation methodology, discusses in detail the process of applying it to the HUMBOLDT project and provides an in-depth analysis of the results, which can be usefully applied to other collaborative research projects in a variety of domains.

1. Introduction

1.1. Problem context

One critical aspect of an Information Technology (IT) based research and development project is the evaluation of its outcomes against its stated objectives and requirements by using a specific evaluation methodology. Undertaking the evaluation of an integrated system is not a simple task for a number of reasons, for example, on time delivery of the different components of the system when: (i) interconnections exist between the various components; (ii) stakeholders are involved from different countries that have diverse backgrounds in respect of technology or application domain; (iii) multiple and sometimes conflicting user-defined and applications specific requirements must be accommodated; (iv) multiple and often conflicting technological research and development objectives must be addressed; and (v) and the evaluation is highly dependent on the availability of resources. All these considerations demand a coherent evaluation methodology, planning to adapt to the varied requirements of collaborative integrated research projects, and use of the available resources in an efficient manner.

In the literature a large number of research and system evaluation approaches, methods and techniques are described (Babar, Zhu, & Jeffery, 2004; Dobrica & Niemela, 2002; Juristo, 1997; Juristo & Morant, 1998; Sommerville, 2006). However, assessment of the outcomes of large-scale integrated and collaborative projects using ad-hoc evaluation approaches has its shortcomings. It may not fully reveal, for example, the limitations and disadvantages of the system. Furthermore any single evaluation methodology or technique may not offer sufficient capacity to fully assess the various aspects of the system that need to be evaluated. As a consequence, it is critical to define the most appropriate evaluation methodologies and techniques for such systems. This paper presents the Criteria Indicators Metrics (CIM) evaluation methodology used to evaluate the EU FP6 HUMBOLDT project (Khan, Ludlow, & Rix, 2013; The HUMBOLDT Project 2006–2011), a large-scale integrated and collaborative research project, with 27 partner organisations plus four sub-contractors from public and private sector representing 14 member states of Europe. The main objective of this paper is to present in-depth analysis of the process of applying CIM to the

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HUMBOLDT project, and reveal its strengths and weaknesses. Furthermore, the paper assesses the extent to which CIM methodology has successfully evaluated the project outcomes against the project's stated and implied objectives. Specification of the overall research outcomes of the project in terms of software tools, components and services are not within the scope of this paper, and are presented elsewhere (Fichtinger et al., 2011; Villa, Molina, Gomarasca, & Roccatagliata, 2012).

1.2. Background and introduction to the HUMBOLDT project

In Europe, the INSPIRE Directive mandates all member states to ensure compliance between their geo-data and INSPIRE specifications (INSPIRE, 2007), so that cross-border unified information can be produced to support better decision-making and policy development. INSPIRE supports a bottom-up perspective for information gathering and monitoring that is complementary to the GMES initiative (Global Monitoring for Environment and Security) (GMES, 2012) that follows a top-down approach for environmental monitoring, for specific application domains such as land, marine, risk management and security.

In relation to the above, the HUMBOLDT project aims to address geospatial data harmonisation by developing state-of-the-art tools, components and services compliant to the INSPIRE and OGC (OGC, 2012) standards. HUMBOLDT Framework services and tools (HUMBOLDT Framework Tools, 2010) include HUMBOLDT GeoModel Editor, HUMBOLDT Alignment Editor (HALE), Workflow Design and Construction Service, Conceptual Schema Translation Service, Edge Matching Service etc. The process for the design and development of these HUMBOLDT tools and services includes: (i) performance of state of the art review of the technology, and (ii) acquisition of stakeholder requirements in respect of various environmental application fields related to GMES applications, known in the HUMBOLDT project as scenarios. Considered only from the perspective of technology, a state-of-the-art literature review could have derived the major requirements for the development of HUMBOLDT Framework. However, such a system would not meet the requirements for full implementation of some solutions, for example those concerning spatial data harmonisation issues faced by various environmental application domain communities. As a consequence, a user perspective was seen as essential to derive the spatial data harmonisation requirements in relation to the various environmental application domains. As a result in addition to the accommodation of user defined requirements from the selected uses cases (e.g. 9 HUMBOLDT scenarios) for various GMES related environmental application domains, it was also possible for HUMBOLDT project partners to derive an evaluation framework for the HUMBOLDT framework and its application to scenarios.

The principal objective of the HUMBOLDT scenarios is deployment of the framework components in the real world. Fundamentally, the HUMBOLDT scenarios provide a community driven research environment that offers feedback on the functionality, usability, benefits and relevance of the HUMBOLDT tools, which thereby contribute towards the full sustainable development of the HUMBOLDT Framework. The HUMBOLDT scenarios include: environmental risk management, forest management, protected areas management, trans-boundary catchment, ocean, air quality (also referred as galileo), urban planning and urban atlas, and border security (HUMBOLDT Scenarios, 2010). These various scenarios deploy real-life considerations to varied European urban and regional contexts, in particular addressing cross-border and cross-thematic data harmonisation challenges that limit the planning and decision making capabilities of policy makers. Essentially, a scenario is a "requirement generator" and therefore central to the user-driven development process. At the same time the scenario is a demonstration activity that articulates the results from the framework and software development process via the applications, which can thereby be used and evaluated by domain expert users and intermediate level users. As a result the HUMBOLDT framework and scenarios can be assessed and proven by demonstrating that they facilitate application developers in the creation of useful software that permit the integrated usage of heterogeneous services and data sources.

The HUMBOLDT evaluation addresses three elements: (i) automated technical validation (HUMBOLDT Technical Evaluation, 2010) using Continuous Integration Server – HUDSON server (HUDSON, 2010), and Code Analysis Server – SONAR (Sonar, 2010); (ii) cost–benefit analysis (Ostreika, 2010); and (iii) user or participatory evaluation. The central interest of this paper is on the participatory or user evaluation element of the overall evaluation framework identified above. This user evaluation was performed on both the HUMBOLDT Framework components, as well as the scenarios. However, the scenario evaluation was complicated e.g. due to licensing issues concerning access to application specific data and proprietary software used by specific scenarios. As a consequence, this evaluation required rigorous collaborative planning, and a structured evaluation methodology to assess the project outputs. This is elaborated in the following sections.

1.3. Related work

The process of defining the evaluation methodology for the HUMBOLDT project builds upon an existing foundation of evaluation methods. The methodology has similarities to GQM (Basili, Caldiera, & Rombach, 1994), and the concerned-based approach (Kotonya & Sommerville, 2002) utilised by (Khan, Odeh, & McClatchey, 2011). In addition, other evaluation methodologies and experience was collected and analysed, especially that applied in Information Technology (IT), Geographical Information Systems (GIS) and Spatial Data Infrastructure (SDI) related research projects. Other considerations included the evaluation concepts developed by the EU funded projects CASCADOSS (CASCADOSS Consortium, 2007), RISE (2007), and WebPark (WebPark consortium, 2002), relevant international standards (ISO/IEC 9126-1, 2001) and additional literature (e.g. RESPECT Consortium, 1998; Tiits, 2003).

In addition to the above, there are a number of research and system evaluation frameworks, methodologies and techniques in the literature (Babar et al., 2004; Dobrica & Niemela, 2002; Juristo, 1997; Juristo & Morant, 1998; Sommerville, 2006) which can be applied to the assessment of specific areas of IT orientated collaborative development projects such as HUMBOLDT. For example, Falessi, Babar, Cantone, and Kruchten (2009) emphasized the view that each software engineering area (i.e. system architecture, reverse engineering, etc.) has specific assessment issues, suggesting that assessment solutions specific for each research area should be developed. Overall we support the views of Falessi et al., but also argue that this approach may not deliver a holistic evaluation necessary for integrated development projects, particularly as such projects frequently involve multiple and cross-disciplinary research areas. All of this indicates the need for an evaluation methodology that unifies the assessment aspects and objectives of different research areas within integrated projects. In addition, IT project evaluation often does not fully accommodate the evaluation objectives of different stakeholders. In this respect, Bryson, Patton, and Bowman (2011) emphasized the need to identify the potential evaluation stakeholder's interests, needs, priorities, concerns, etc. in planning, designing and applying evaluation based on different techniques. These techniques facilitate step-by-step participatory evaluation for collaborative